AMENDMENTS TO THE CLAIMS

The following listing of claims will replace all prior versions and listings of claims in the application.

LISTING OF CLAIMS

1. An interactive system for local intervention inside a region of a non-homogeneous structure to which is connected a reference structure containing a plurality of base points, the interactive system comprising:

means for dynamically displaying a three-dimensional image of a representation of the non-homogeneous structure and of the reference structure connected to the non-homogeneous structure, wherein the three-dimensional image also includes a plurality of images of the plurality of base points;

means for determining a set of coordinates of the plurality of images of the plurality of base points in a first reference frame;

means for fixing a position of the non-homogeneous structure and of the reference structure with respect to a second reference frame;

means for determining a set of coordinates of the plurality of base points in the second reference frame;

means of intervention comprising an active member whose position is determined with respect to the second reference frame;

means for generating a plurality of reference frame translation tools for translating a plurality of reference frames from the first reference frame to the second reference frame and vice versa, based on the set of coordinates of the plurality of

images of the plurality of base points in the first reference frame and of the set of coordinates of the plurality of base points in the second reference frame, in such a way as to reduce to a minimum at least one of a set of deviations between the set of coordinates of the plurality of images of the plurality of base points in the first reference frame and the set of coordinates of the base points, expressed in the first reference frame using the plurality of reference frame translation tools;

means for defining, with respect to the first reference frame, a simulated origin of intervention and a simulated direction of intervention; and,

means for transferring the plurality of reference frames using the plurality of reference frame translation tools to establish a bidirectional coupling between the simulated origin of intervention and the simulated direction of intervention and the position of the active member.

2. The interactive system according to claim 1, wherein the plurality of reference frame translation tools comprise:

means for creating a matrix (M) for transferring between the first reference frame and a first intermediate reference frame based on a set of coordinates of a set of three images of a set of three base points of the reference structure;

means for creating a matrix (N) for transferring between the second reference frame and a second intermediate reference frame based on the set of coordinates of the set of three images of the set of three base points of the reference structure; and,

means for validating matrix (M) and matrix (N) based on the set of three base points and the set of three images, such that at least one deviation between an expression for at least one additional base point in the second intermediate reference frame and an expression for at least one image point of the additional base point in the first intermediate reference frame is reduced to a minimum.

3. The interactive system according to plurality of claim 2, wherein the means for transferring the reference frames using the plurality of reference frame translation tools further comprises:

a first transfer sub-module for transferring a set of representation/non-homogeneous structure coordinates, and

a second transfer sub-module for transferring a set of non-homogeneous structure/representation coordinates.

4. The interactive system according to claim 3, wherein the first transfer sub-module comprises:

means for acquiring a set of coordinates (XM, YM, ZM), expressed in the first reference frame, of a point of the representation of the non-homogeneous structure to be transferred, by selection on the representation;

means for calculating a set of corresponding coordinates (XP, YP, ZP), expressed in the second reference frame, on the non-homogeneous structure through a transformation:

{YP,YP, ZP}=M*N.sup.-1 *{XM,YM,ZM} where M * N.sup.-1 represents a product of the matrix (M) and an inverse of the matrix (N), and

means for processing, with the aid of the corresponding coordinates (YP, YP, ZP), to display a corresponding point on a surface of the non-homogeneous structure and to secure the intervention.

5. The interactive system according to claim 3, wherein the second transfer sub-module comprises:

means for acquiring a set of coordinates (XP, YP, ZP), expressed in the second reference frame, of a point of the non-homogeneous structure to be transferred;

means for calculating a set of corresponding coordinates (XM YM, ZM), expressed in the first reference frame, of the representation through a transformation:

{YM, YM, ZM}=N*M.sup.-1 *{XP,ZP,ZP} where N*M.sup.-1 represents the product of the matrix (N) and an inverse of the matrix (M); and,

means for displaying the representation using the set of corresponding coordinates (YM, YM, ZM).

6. The interactive system according to claim 1, wherein the means for generating the plurality of reference frame translation tools also generate, in association with the reference frame translation tools, tools for taking into account a residual uncertainty which is based on the set of deviations between the set of coordinates of the plurality of images of the plurality of base points in the first reference frame and the set of coordinates of the base points, the tools for taking into account the residual

uncertainty usable for displaying a set of contours in the representation whilst taking into account the residual uncertainties.

7. The interactive system according to claim 1, wherein the means of dynamic displaying the three-dimensional image comprises:

a file containing digitized data from a set of two-dimensional images constituted by successive non-invasive tomographic sections of the non-homogeneous structure;

means for calculating and reconstructing the three-dimensional image from the set of two-dimensional images; and

a high-resolution display screen.

8. The interactive system according to claim 7, wherein the means for calculating and reconstructing the three-dimensional image from the set of two-dimensional images comprises a program consisting of computer-aided design type software.

9. The interactive system according to claim 1, wherein the means for determining the set of coordinates of the plurality of base points in the second reference frame comprises a three-dimensional probe equipped with a tactile tip for delivering a set of coordinates of the tactile tip in the said second reference frame.

10. The interactive system according to claim 1, wherein the means for determining the set of coordinates of the plurality of base points is the second reference frame comprises at least one of a set of optical sensors and a set of electromagnetic sensors.

11. The interactive system according to claim 1, wherein a portion of the set of the plurality of base points of the reference structure comprises a plurality of marks positioned on a lateral surface of the non-homogeneous structure.

12. The interactive system according to claim 11, wherein the plurality of marks are four in number and are distributed over the lateral surface so as to define a substantially symmetrical tetrahedron.

13. The interactive system according to claim 1, wherein the means of intervention comprises:

a guide arm to secure intervention in the region of the non-homogeneous structure, the guide arm having a position marked with respect to the second reference frame; and,

an active intervention member whose position is marked with respect to the second reference frame.

14. The interactive system according to claim 13, wherein the active intervention member is removable and selected from the group consisting of:

tools for trephining;

needles and implants;

laser and radioisotope emission heads; and, sighting and viewing systems.

15. The interactive system according to claim 1, wherein the means for transferring the plurality of reference frames establishes a coupling between a direction of visualization of the representation of the non-homogeneous structure on the display means and a direction of observation of the non-homogeneous structure and of the reference structure by the active intervention member.

16. The interactive system according to claim 15, further comprising:

a first module for visualizing a representation in a direction given by two points;

a second module for visualizing a representation in a direction given by an angle of elevation and an angle of azimuth.

17. (Canceled)

18. (Canceled)

19. (Twice Amended) An interactive system for intervention inside a region of a patient, said interactive system comprising:

a device operable to receive image data of the region of the patient, wherein the image data includes image data of a first reference structure to establish an image reference frame for the region of the patient;

a second reference structure positioned relative to the patient to establish a patient reference frame for the region of the patient;

a controller operable to correlate the position of the first reference structure in the image reference frame with the position of the second reference structure in the patient reference frame;

an active member operable to perform the intervention; and

a tracking system operable to determine a position of at least the second reference structure and a position of the active member and configured to transmit the determined positions of the second reference structure and the active member to the controller;

wherein the controller is configured to determine the position of the active member based on the determined position of at least the active member and the correlation of the first reference structure and the second reference structure.

20. (previously presented) The interactive system as defined in Claim 19 wherein the first reference structure includes a plurality of base points.

21. (previously presented) The interactive system as defined in Claim 20 wherein the second reference structure includes a plurality of tracking markers.

22. (previously presented) The interactive system as defined in Claim 19 wherein the second reference structure includes a plurality of tracking markers.

23. (previously presented) The interactive system as defined in Claim 22 wherein the plurality of tracking markers are attached to the patient.

24. (previously presented) The interactive system as defined in Claim 19 wherein the second reference structure is attached to the patient.

25. (previously presented) The interactive system as defined in Claim 19 wherein the first reference structure is attached to the patient.

26. (previously presented) The interactive system as defined in Claim 21 wherein the plurality of base points are generated from the plurality of tracking markers.

27. (previously presented) The interactive system as defined in Claim 20 wherein the plurality of base points are at least one of a plurality of notable points on the patient and marks fixed to the patient.

28. (previously presented) The interactive system as defined in Claim 27 wherein the notable points are selected from a group comprising a head, eyebrows, temples, frontal medial point, an apex of a skull, a center of gravity of an orbits of the eyes and a combination thereof.

29. (previously presented) The interactive system as defined in Claim 19 wherein the tracking system includes a marker device operable to determine a position of the second reference structure in relation to the patient reference frame.

30. (Amended) The interactive system as defined in Claim 29 wherein the marker device includes a telemetry system operable to determine the position of the second reference structure in the patient reference frame and transmit the determined position to the controller, wherein the controller is operable to perform the correlation at least with the transmitted determined position.

31. (previously presented) The interactive system as defined in Claim 30 wherein the telemetry system is an electromagnetic telemetry system.

32. (previously presented) The interactive system as defined in Claim 31 wherein the second reference structure includes electromagnetic tracking markers, wherein the electromagnetic telemetry system is operable to determine the position of the electromagnetic tracking markers of the second reference structure in relation to the patient reference frame.

33. (previously presented) The interactive system as defined in Claim 32, wherein the electromagnetic tracking markers are transmitters and the electromagnetic telemetry system is an electromagnetic sensor.

34. (previously presented) The interactive system as defined in Claim 30 wherein the telemetry system is an optical telemetry system.

35. (Amended) The interactive system as defined in Claim 34 wherein the optical telemetry system includes at least one of a video camera or an infrared camera to image at least the second reference structure and configured to plot points of the second reference structure.

36. (previously presented) The interactive system as defined in Claim 34 wherein the second reference structure includes optical tracking markers, wherein the optical telemetry system is operable to determine the position of the optical tracking markers of the second reference structure in relation to the patient reference frame.

37. (previously presented) The interactive system as defined in Claim 34 wherein the optical telemetry system utilizes position and shape recognition to identify the second reference structure.

38. (previously presented) The interactive system as defined in Claim 29 wherein the marker device includes a three-dimensional probe.

39. (previously presented) The interactive system as defined in Claim 38 wherein the three-dimensional probe includes a tactile tip operable to engage the second reference structure.

40. (previously presented) The interactive system as defined in Claim 38 wherein the three-dimensional probe is robotically manipulated, such that the instantaneous position of the three-dimensional probe is known.

41. (previously presented) The interactive system as defined in Claim 29 wherein the marker device includes a set of cameras operable to determine the position of the second reference structure in relation to the patient reference frame.

42. (previously presented) The interactive system as defined in Claim 41 wherein the set of cameras are selected from video and infrared cameras.

43. (previously presented) The interactive system as defined in Claim 29 wherein the marker device is a laser beam emission system operable to illuminate the second reference structure to determine a position of the second reference structure in relation to the patient reference frame.

44. (previously presented) The interactive system as defined in Claim 20 wherein the controller further includes a graphical tool operable to identify the plurality of

base points of the first reference structure in the image data of the image data reference frame.

45. (previously presented) The interactive system as defined in Claim 44 wherein the graphical tool is a mouse in communication with the controller.

46. (previously presented) The interactive system as defined in Claim 19 wherein the first reference structure is generated from the second reference structure.

47. (canceled)

48. (Amended) The interactive system as defined in Claim 19 wherein the active member is selected from a group comprising a trephining tool, a needle, a laser, a radioscope emission head, an endoscopic viewing system, a tool used in the intervention, an implant, a sighting system, a microscope, and combinations thereof.

49. (Amended) The interactive system as defined in Claim 19 further comprising a telemetry system operable to determine the position of the active member in the patient reference frame, said telemetry system in communication with the controller.

50. (previously presented) The interactive system as defined in Claim 49 wherein the position information of the active member is six degree of freedom information in relation to the patient reference frame.

51. (Amended) The interactive system as defined in Claim [[47]] 19 wherein the device includes a display operable to display the image data of the region of the patient in relation to the image reference frame.

52. (previously presented) The interactive system as defined in Claim 51 wherein the controller is further operable to determine a reference origin of intervention and a direction of intervention and said display is further operable to display the reference origin of intervention and direction of intervention.

53. (previously presented) The interactive system as defined in Claim 51 wherein the controller is further operable to model a reference origin of intervention and a direction of intervention and said display is further operable to display the modeled reference origin of intervention and direction of intervention.

54. (Amended) The interactive system as defined in Claim 51 wherein the display is further operable to display the real-time position of the active member in the image reference frame based on the determined position of the active member with the tracking system.

55. (previously presented) The interactive system as defined in Claim 51 wherein the display is further operable to display image data relative to a direction of intervention of the active member.

56. (previously presented) The interactive system as defined in Claim 55 wherein the image data is displayed perpendicular to a direction of intervention of the active member.

57. (previously presented) The interactive system as defined in Claim 51 wherein the controller is further operable to simulate an optimal trajectory of advance of the active member and said display is operable to display the optimal trajectory in the image data relative to the image reference frame.

58. (previously presented) The interactive system as defined in Claim 57 wherein movement of the active member is steered to the optimal trajectory to carry out a programmed intervention.

59. (Amended) The interactive system as defined in Claim 19 wherein the active member is robotically controlled.

60. (previously presented) The interactive system as defined in Claim 19 wherein the image data is at least one of a magnetic resonance image data, a

tomographic image data, a radiographic image data, x-ray image data, and combinations thereof.

61. (previously presented) The interactive system as defined in Claim 19 wherein the device is operable to construct three-dimensional images from captured two-dimensional images.

62. (previously presented) An interactive system for intervention inside a region of a patient, said interactive system comprising:

a device operable to receive image data of the region of the patient, wherein the image data includes image data of a first reference structure to establish an image reference frame for the region of the patient;

a second reference structure positioned relative to the patient to establish a patient reference frame for the region of the patient; and

a controller operable to correlate the position of the first reference structure in the image reference frame with the position of the second reference structure in the patient reference frame;

wherein the device is operable to construct three-dimensional images from captured two-dimensional images;

wherein the controller is operable to superimpose two-dimensional image data on the three-dimensional images wherein any change in soft external parts of the patient can be visualized as compared with the image captured by the imaging device.

63. (previously presented) An interactive system for intervention inside a region of a patient, said interactive system comprising:

a device operable to receive image data of the region of the patient, wherein the image data includes image data of a first reference structure to establish an image reference frame for the region of the patient;

a second reference structure positioned relative to the patient to establish a patient reference frame for the region of the patient;

a controller operable to correlate the position of the first reference structure in the image reference frame with the position of the second reference structure in the patient reference frame; and

an active member operable to perform the intervention;

wherein the device includes a display operable to display the image data of the region of the patient in relation to the image reference frame;

wherein the controller is further operable to determine residual uncertainty which is used to represent a contour with dimensions larger than those which would normally be represented and the display is operable to display the residual uncertainty of the contour.

64. (previously presented) The interactive system as defined in Claim 63 wherein the contour is a display of an active member and a representation of residual uncertainty in order to reduce the chance of traversing undesired structures.

65. (previously presented) The interactive system as defined in Claim 19 wherein the controller is further operable to correlate map data in a map reference frame with the patient reference frame.

66. (Amended) The interactive system as defined in Claim 19 wherein the intervention is at least one of a neurosurgery, orthopedic surgery, cranial surgery, and combinations thereof.

67. (previously presented) The interactive system as defined in Claim 19 wherein the second reference structure is fixed to a head set.

68. (previously presented) The interactive system as defined in Claim 60 wherein the head set is further fixed to an operating table.

69. (previously presented) The interactive system as defined in Claim 19 wherein the device further includes memory operable to store the image data.

70. (previously presented) The interactive system as defined in Claim 19 wherein the device is a first computer.

71. (previously presented) The interactive system as defined in Claim 70 wherein the controller is a second computer.

72. (previously presented) The interactive system as defined in Claim 71 wherein the first computer and the second computer is a single work station.

73. (Twice Amended) An interactive system for intervention inside a region of a patient, said interactive system comprising:

a device operable to receive image data of the region of the patient, wherein the image data includes image data of a first reference structure to establish an image reference frame for the region of the patient;

a second reference structure positioned relative to the patient to establish a patient reference frame for the region of the patient;

a controller operable to correlate the position of the first reference structure in the image reference frame with the position of the second reference structure in the patient reference frame;

an active member operable to perform the intervention inside the region of the patient;

a tracking system operable to track the position of the active member in relation to the patient reference frame, the tracking system being in communication with the controller to transmit the tracked position of the active member as position information to the controller, wherein the controller is operable to determine the position of the active member relative to the image reference frame; and

a display operable to display the real-time position of the active member in the image reference frame based on the controller determined position of the active member based on the tracked position of the active member from the tracking system, wherein the controller is configured to generate a representation of the active member that is displayed on the display relative to a display of the received image data.

74. (previously presented) The interactive system as defined in Claim 73 wherein the active member is selected from a group comprising a trephining tool, a needle, a laser, a radioscope emission head, an endoscopic viewing system, a tool used in the intervention, an implant, a sighting system, a microscope, and combinations thereof.

75. (previously presented) The interactive system as defined in Claim 73 wherein the position information of the active member is six degree of freedom information in relation to the patient reference frame.

76. (previously presented) The interactive system as defined in Claim 73 wherein the tracking system that tracks the position of the active member is a telemetry system in communication with the controller.

77. (previously presented) The interactive system as defined in Claim 73 wherein the active member is robotically controlled.

78. (previously presented) The interactive system as defined in Claim 73 wherein the image data is at least one of a magnetic resonance image data, a tomographic image data, a radiographic image data, x-ray image data, and combinations thereof.

79. (previously presented) The interactive system as defined in Claim 73 wherein the controller is further operable to determine a reference origin of intervention and a direction of intervention and said display is further operable to display the reference origin of intervention and direction of intervention.

80. (previously presented) The interactive system as defined in Claim 73 wherein the first reference structure includes a plurality of base points.

81. (previously presented) The interactive system as defined in Claim 80 wherein the second reference structure includes a plurality of tracking markers.

82. (previously presented) The interactive system as defined in Claim 81 wherein the plurality of base points are generated by the plurality of tracking markers.

83. (previously presented) The interactive system as defined in Claim 73 wherein the second reference structure is attached to the patient.

84. (previously presented) The interactive system as defined in Claim 73 wherein intervention is at least one of a neurosurgery, orthopedic surgery, cranial surgery intervention, and combinations thereof.

85. (previously presented) The interactive system as defined in Claim 73 wherein the second reference structure is fixed to a head set.

86. (Amended) The interactive system as defined in Claim 73 wherein the display forms part of the device and wherein the image data received is acquired image data of the region of the patient and is displayed on the display, further wherein the representation of the active member is displayed on the acquired image data of the region of the patient.

87. (Twice Amended) A method for performing an image guided intervention inside a region of a patient, said method comprising:

accessing a first image data of the region of the patient captured with an imaging system where the first image data includes image data of a first reference structure;

identifying the first reference structure in the first image data to establish an image reference frame;

identifying a second reference structure relative to the patient to establish a patient reference frame;

correlating the position of the first reference structure in the image reference frame in the first image data with the position of the second reference structure in the patient reference frame; and

tracking an active member at least to determine a position of the active member in the patient reference frame to determine a location of the active member based on the tracking of the active member and transmitting the determined position in the patient refrence frame for display on a display device relative to the image reference frame of the first image data based at least on the correlation of the first reference structure and the second reference structure.

88. (previously presented) The method as defined in Claim 87 further comprising attaching a plurality of tracking markers to the patient where the tracking markers form the second reference structure.

89. (previously presented) The method as defined in Claim 88 further comprising identifying the position of the tracking markers in the patient reference frame using a telemetry system.

90. (Amended) The method as defined in Claim 89 further comprising transmitting from the tracking markers a signal and receiving the transmitted signal with an electromagnetic sensor to identify the position of the second reference structure in the patient reference frame.

91. (previously presented) The method as defined in Claim 87 wherein identifying the first reference structure includes identifying a plurality of base points visible in the image data.

92. (previously presented) The method as defined in Claim 91 wherein identifying the plurality of base points includes identifying at least one of notable points on the patient as marks fixed to the patient representing the plurality of base points.

93. (previously presented) The method as defined in Claim 92 wherein the notable points are selected from a group comprising a head, eyebrows, temporal point, frontal medial point, an apex of a skull, a center of gravity of an orbits of the eyes and a combination thereof.

94. (previously presented) The method as defined in Claim 91 wherein the plurality of base points visible in the image data are generated from the plurality of tracking markers attached to the patient.

95. (previously presented) The method as defined in Claim 87 further comprising attaching the second reference structure to the patient.

96. (previously presented) The method as defined in Claim 87 further comprising displaying the image data of the region of the patient, including displaying the first reference structure.

97. (previously presented) The method as defined in Claim 87 further comprising performing an intervention on the patient with an active member.

98. (Canceled)

99. (Amended) The method as defined in Claim 96 further comprising:

displaying the position of the active member as a representation of the active member in the accessed first image data that is captured image data that is correlated to the patient based on the correlation and displayed on a display device with the position of the active member being correlated between the patient reference frame defined by the first reference structure fixed to the patient and the image reference frame based on the tracking of the active member.

100. (Amended) The method as defined in Claim 99 further comprising identifying the position of the active member with a telemetry system by transmitting the tracked location of the active member for displaying the representation of the active member.

101. (previously presented) The method as defined in Claim 99 further comprising displaying a reference origin of intervention and a direction of intervention in the image data.

102. (previously presented) The method as defined in Claim 101 further comprising tracking the position of the active member relative to the reference origin of intervention and the direction of intervention.

103. (previously presented) The method as defined in Claim 87 further comprising converting two-dimensional image data to three-dimensional image data.

104. (previously presented) The method as defined in Claim 97 wherein the intervention is selected from at least one of a neurosurgery, orthopedic surgery, cranial surgery, and combinations thereof.

105. (previously presented) The method as defined in Claim 95 further comprising attaching the second reference structure to a head set.